BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B71 02045

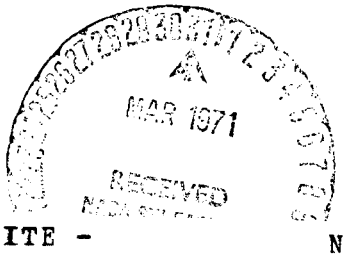
SUBJECT: P&F Subsatellite - Fail Safe S-Band Transmitter Control. Case 320

DATE: February 17, 1971

FROM: A. G. Weygand

ABSTRACT

Since the Particles and Fields (P&F) Subsatellite will be provided with an S-band transponder whose operating frequencies will be identical to those currently assigned to the Lunar Module (LM), concern has been expressed that Subsatellite S-band transmissions could interfere with LM to Manned Space Flight Network (MSFN) transmissions. Immediately after ejection of the Subsatellite from the Command and Service Module (CSM) of Apollo 15 into lunar orbit, the receiver of the Subsatellite S-band transponder will be automatically activated enabling commands transmitted by an MSFN station to be received and executed by the Subsatellite. A number of different Subsatellite operating modes selectable by ground command require the transmitter of the S-band transponder to be activated; namely, (a) real-time, (b) memory read-out, (c) automatic cycle, and (d) coherent tracking modes. If at any time it was possible that Subsatellite transmissions could interfere with the mission of any LM, the Subsatellite could be commanded from the ground into an operating mode not requiring the transmitter of the S-band transponder to be active as long as the command system of the Subsatellite remained operable. If the Subsatellite command system were to fail when the Subsatellite was in an operating mode with the transmitter of the S-band transponder active, the transmitter could operate intermittently for as long as 18 days, or continuously for a considerably shorter time period as short as 5 hours, before automatic transmitter control circuitry would deactivate the transmitter. This transmitter control circuitry as applied to the various Subsatellite operating modes which utilize the transmitter of the S-band transponder is discussed in this memorandum.



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MEMORANDUM FOR FILE

At some time after the insertion of the Command and Service Module (CSM) of Apollo 15 into lunar orbit, the Particles and Fields (P&F) Subsatellite will be ejected from the Scientific Instrument Module (SIM) in the Service Module into lunar orbit by its spring activated separation mechanism upon command by a crewman in the Command Module. The P&F Subsatellite will be provided with S-band communications equipment which will enable stations of the Manned Space Flight Network (MSFN) to track the Subsatellite using Doppler frequency measurements, to receive subsystems status and experiment data from the Subsatellite, and to transmit commands to the Subsatellite. Immediately upon separation from the CSM, the S-band receiver of the Subsatellite S-band communications equipment will be automatically activated enabling commands transmitted by a station of the MSFN to be received and executed by the Subsatellite. There will be a number of different modes of operation of the Subsatellite which will be selectable by ground command, several of which will require the S-band transmitter of the Subsatellite to be activated. Since the operating carrier frequencies assigned to the Subsatellite S-band transponder will be identical to those currently assigned to the Lunar Module (LM), namely, 2101.8 MHz receive and 2282.5 MHz transmit, concern has been expressed that Subsatellite transmissions could interfere with LM to MSFN transmissions if the command reception system of the Subsatellite were to fail after the Subsatellite was commanded into an operating mode which required the S-band transmitter of the Subsatellite to be active. In response to this concern, the fail safe methods to be incorporated in the Subsatellite to insure that the S-band transmitter, if operating, would be deactivated after some nominal time period if command capability to the Subsatellite were lost are briefly outlined in the following paragraphs. The information contained herein was obtained during the Critical Design Review (CDR) for the P&F Subsatellite held on July 14 and 15, 1970 and during a telephone conversation with Mr. J. H. Booker, MSC/EE17, on February 16, 1971.

The modes of operation of the Subsatellite which require its S-band transmitter to be active include:

(a) Real-time Mode - Subsatellite subsystems status and experiment data are sampled and transmitted continuously.

(b) Memory read-out mode - Stored experiment data is read out of the on-board memory and combined with Subsatellite subsystems status data obtained in real-time and the resultant data composite is transmitted.

(c) Automatic cycle mode - Upon initiation of this mode, the following sequence of operations is performed automatically and repeated continuously: (1) switch on the real-time mode for 300 to 450 seconds, (2) switch on the memory read-out mode for 512 seconds, and (3) switch on the data storage normal mode for 6144 seconds.

(d) Coherent tracking mode - Subsatellite transmitter is activated only when the S-band receiver is phase-locked to an uplink carrier frequency so that the transmitted carrier and uplink carrier frequencies are phase coherent.

The primary source of power for Subsatellite operation will be an array of solar cells mounted on the sides of the Subsatellite while a rechargable silver - cadmium battery will provide the necessary power for Subsatellite operation during periods of solar eclipse or when the Subsatellite load requires more power than is generated by the solar array alone. When the S-band transmitter is operating, the power supplied by the solar array will be insufficient and the additional power required will be drawn from the battery. It has been estimated that the S-band transmitter could operate in the real-time mode for approximately 5 hours with the Subsatellite in solar eclipse (or proportionately longer depending upon the time spent in eclipse) before the battery undervoltage protection circuitry would automatically deactivate the transmitter and put the Subsatellite in a "stand-by" mode. In the stand-by mode of operation of the Subsatellite, no data will be stored or transmitted and the S-band transmitter will be inactive. The Subsatellite will remain in this stand-by mode, even after the battery has been recharged, until a mode change command is received from a station of the MSFN.

Whenever the Subsatellite is commanded into the memory read-out mode, it will remain in that mode until the contents of the on-board memory have been completely read out and transmitted. At completion of memory read-out, the Subsatellite will automatically switch into the stand-by mode of operation and

remain in that mode until a mode change command is received from a station of the MSFN.

The most likely mode for continuous Subsatellite transmission is the automatic cycle mode. It has been estimated from a power budget viewpoint that the Subsatellite could operate indefinitely in the automatic cycle mode. Thus the S-band transmitter would be active for approximately 15 minutes during each Subsatellite revolution about the Moon. To avoid being locked into this mode of operation if command capability to the Subsatellite were lost with the resulting creation of a potential radio frequency interference source, logic circuitry has been incorporated into the Subsatellite. Upon Subsatellite activation, this logic circuitry will be activated and after 12 days the circuitry will be armed. Unless this logic circuitry is reset within 6 days, the transmitter will be turned off at the end of this 6 day period. If this logic circuitry is reset within 6 days, it must be reset again within a 6 day period or the transmitter will be inhibited at the end of this last 6 day period. If the logic circuitry is allowed to inhibit the transmitter, the logic circuitry can be reinitialized through action by ground control allowing the transmitter to be reactivated. At the end of a 12 day period after reinitialization, the logic circuitry will again become armed as discussed above.

Consequently, the S-band transmitter would continue to operate once per lunar revolution for from 6 to 18 days after command capability to the Subsatellite was lost if the Subsatellite was in the automatic cycle mode depending upon the slate of this logic circuitry when the command capability was lost. This logic circuitry will be reset (or reinitialized as the case may be) whenever a signal called a message acceptance pulse (MAP) generated by the Subsatellite command decoder appears except during the 12 day period after reinitialization when no action is taken. The MAP is normally generated by the command decoder and routed to the Subsatellite telemetry system for transmission to the MSFN whenever the command decoder receives and decodes a valid command message transmitted by the MSFN.

When the Subsatellite is operating in the coherent tracking mode, the transmitter will not be activated unless the Subsatellite S-band receiver is phase-locked to an uplink carrier frequency. If the Subsatellite was operating in the coherent tracking mode when command capability to the Subsatellite was lost, no radio frequency interference with LM transmissions would occur unless the MSFN transmissions to the LM were also received by the Subsatellite. This would occur whenever the LM and the Subsatellite were both within the beamwidth of the S-band antenna of an operating MSFN station. However,

as for the case discussed above where the Subsatellite was operating in the automatic cycle mode when command capability was lost, the S-band transmitter would be inhibited after from 6 to 18 days after loss of command capability to the Subsatellite.

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From: A. G. Weygand

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